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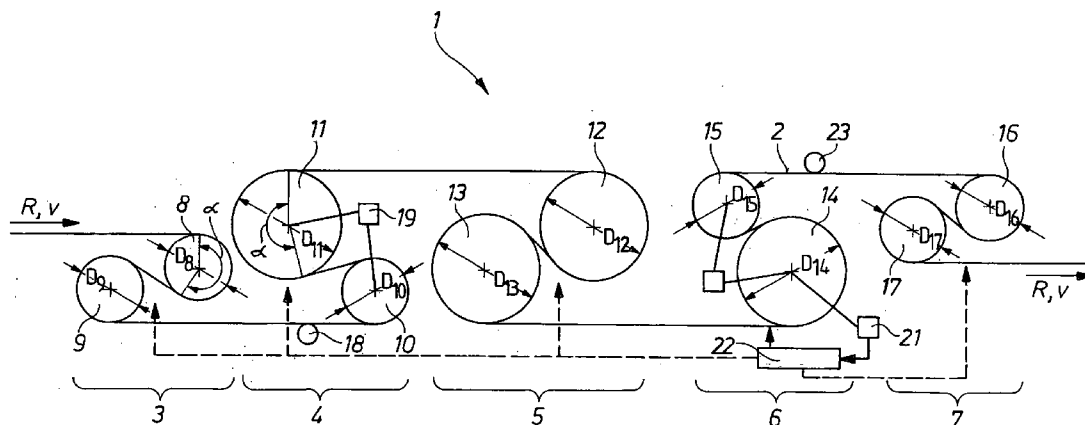
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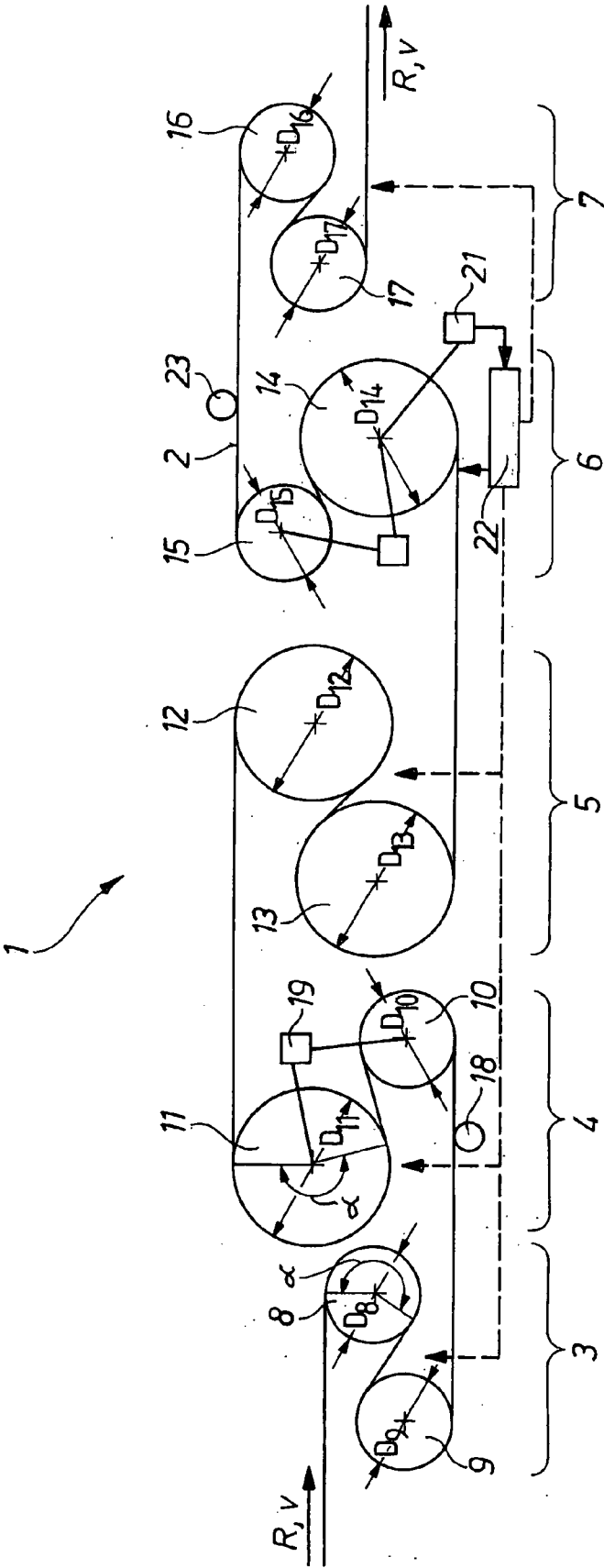
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NEW YORK, NY 10017 (US)(57) **ABSTRACT**

The invention relates to a device (1) for the continuous lengthening of a metal strip (2) by traction, said device comprising, in the strip transporting direction (R), at least three S-roll units (3, 4, 5, 6, 7) each provided with at least two rolls (8, 9, 10, 11, 12, 13, 14, 15, 16, 17). According to the invention, the rolls (8, 9, 10, 11, 12, 13, 14, 15, 16, 17) are positioned in such a way that the metal strip (2) is wound round them at a roll periphery angle (α) of more than 180° , and at least the second S-roll unit (4) in the strip transporting direction (R) comprises two rolls (10, 11) with different-sized diameters (D_{10} , D_{11}).

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**DEVICE FOR THE CONTINUOUS LENGTHENING
OF A METAL STRIP BY TRACTION, AND
METHOD FOR OPERATING ONE SUCH DEVICE**

[0001] The invention concerns a device for the continuous stretcher leveling of metal strip, which device has at least three bridles in the direction of strip transport, with each bridle having at least two rolls, which are positioned in such a way that the metal strip wraps around them over a contact roll wrap angle of more than 180°. The invention also concerns a method for operating a device of this type.

[0002] EP 0 393 301 B2 discloses a device for the stretcher leveling of metal strip and a corresponding method for operating it. The metal strip to be stretched passes through five bridles arranged in succession, which cause the metal strip to wrap around the rolls in the shape of an S and can cause tensile stress to build up in the metal strip by suitable driving of the bridle rolls. Plastic elongation of the metal strip takes place during the stretching operation, and this leads to a reduction of the strip thickness and strip width.

[0003] During this operation, in a first stretcher leveling zone, a tensile stress is built up which almost reaches the yield point ($\sigma_{p0.2}$) or even exceeds it. In the event that the strip tension remains just below the yield point, a prestretching zone, in which the strip width is elastically reduced, forms around the roll of the bridle in conjunction with the finite bending radius. The actual stretching is produced in a second stretcher leveling zone that is located downstream in the direction of strip transport. By dividing the stretcher leveling into two zones, the flatness result in the metal strip after the stretcher leveling is improved.

[0004] In the solution disclosed in EP 0 393 301 B2, the strip tension for the elastic deformation of the strip is applied between a brake roll set and a tension roll set. The strip tension for the plastic deformation of the strip is produced in a pair of stretcher leveling rolls arranged between them.

[0005] EP 0 936 954 B1 discloses a stretcher leveling installation in which the two stretching zones are formed between a brake roll set and a centrally arranged stretcher roll and between this stretcher roll and a downstream tension roll set.

[0006] Furthermore, EP 1 245 301 A2 discloses an installation in which the two stretching zones are formed between the brake roll set and a driven roll and between this roll and the tension roll set. It is provided that the length of the first and the second stretching interval or stretching zone is at least 0.5 times the maximum strip width, which is intended to improve the flatness result of the stretching operation.

[0007] Finally, DE 36 36 707 C2 describes a stretcher leveling installation for metal strip, in which the flatness-improving effect is achieved by stretching the strip by means of bending in alternating directions under tension around small rollers.

[0008] Although the previously known devices for the stretcher leveling of metal strip and the previously known methods already make it possible to increase the degree of flatness of metal strip, there is a need to create installations and methods that are further improved, so that metal strip can be subjected to stretcher leveling that is even more efficient.

[0009] Therefore, the objective of the invention is to create a stretcher leveling device of the aforementioned type and a corresponding stretcher leveling method, with which the stretcher leveling operation can be further improved.

[0010] In accordance with the invention, the solution to this problem with respect to a device is characterized by the fact that at least the second bridle of the stretcher leveling device in the direction of strip transport has two rolls with different diameters.

[0011] As will become apparent later, this measure results in an improvement in the stretcher leveling operation, and this in turn leads to improved flatness of the processed metal strip.

[0012] It is preferred for the roll with the larger diameter to be the downstream roll of the second bridle.

[0013] In accordance with a preferred embodiment, the device has five bridles with at least two rolls each. In this connection, the fourth bridle in the direction of strip transport can have two rolls with different diameters. In addition, in this case, the roll with the smaller diameter can be the downstream roll of the fourth bridle.

[0014] The diameter of the bridle roll with the larger diameter is preferably at least 1.25 times larger than the diameter of the bridle roll with the smaller diameter. The diameter of the bridle roll with the larger diameter is preferably at least 1.5 times larger than the diameter of the bridle roll with the smaller diameter, and especially twice as large.

[0015] In accordance with a further refinement of the invention, the third bridle has two rolls with diameters that are the same as the diameters of the larger rolls of the second and fourth bridles. Furthermore, the first and fifth bridles can each have two rolls with diameters that are the same as the diameters of the smaller rolls of the second and fourth bridles.

[0016] Means for measuring the tensile force present in the metal strip can be installed after the first bridle in the direction of strip transport. The second bridle in the direction of strip transport can be equipped with means for measuring the tensile force applied to the metal strip by the rolls. In addition, the fourth bridle in the direction of strip transport can be equipped with means for measuring the tensile force applied to the metal strip by the rolls.

[0017] An advantageous "speedmaster" operation can be realized if the fourth bridle in the direction of strip transport is equipped with measuring means for measuring the speed of conveyance of the metal strip, which means are connected with an open-loop or closed-loop control system, which regulates or automatically controls the drives of at least some of the bridles according to the determined speed of conveyance.

[0018] The method of the invention for operating the stretcher leveling device is characterized by the fact that in the second bridle in the strip transport direction, a tensile stress is built up in the metal strip which is 96% to 100% of the yield point of the material of the metal strip. The tensile stress is preferably 96% to 99.8% of the yield point of the material, i.e., just below 100% of the yield point of the material.

[0019] In a device with five bridles, a tensile stress that is greater than 100% of the yield point of the material of the metal strip is preferably built up in the metal strip in the third bridle in the direction of strip transport.

[0020] In addition, it can be provided that, in the fourth bridle in the strip transport direction, a tensile stress is built up in the metal strip which is 96% to 100% of the yield point of the material of the metal strip or again is just below the yield point (up to 99.8% of the yield point). As an alternative to this, a tensile stress that is greater than 100% of the yield point of the material of the metal strip can be built up in the metal strip in the fourth bridle in the direction of strip transport. Accordingly, the metal strip is further plastically deformed.

[0021] The sole figure is a highly schematic representation of a specific embodiment of the invention. It shows a side view of a device for the stretcher leveling of metal strip, and basically only the rolls that are used are illustrated in the drawing.

[0022] A metal strip 2, which can be a thin metal strip, is processed in the stretcher leveling device 1 illustrated in the drawing. The metal strip can consist of steel, high-grade steel, or nonferrous metal. Typical strip thicknesses can be 0.05 to 0.5 mm.

[0023] The stretcher leveling device 1 has five bridles 3, 4, 5, 6, and 7 arranged in succession. Each bridle 3, 4, 5, 6, 7 has two rolls 8, 9; 10, 11; 12, 13; 14, 15; and 16, 17, respectively. The rolls are arranged in such a way that the metal strand 2 wraps around them over a contact roll wrap angle α of at least 180° . The contact roll wrap angle α is shown for rolls 8 and 11 by way of example: it is about 210° . The rolls can be driven, so that strip tension can be applied to the metal strand 2.

[0024] The metal strip 2 passes through the device 1 in strip transport direction R at a conveyance speed v.

[0025] The strip tension is increased from the surrounding installation tension level by means of the first bridle 3 on the entry side. Means 18 for measuring the tensile force in the metal strip 2 are installed downstream of the bridle 3. The tensile force downstream of the bridle 3 must be known to be able to define and then regulate or automatically control the tension level for the further controlled tension buildup.

[0026] The following bridle 4 has the two rolls 10 and 11, which have significantly different diameters, namely, diameters D_{10} and D_{11} . The roll diameter D_{10} can be about 600 mm (values between 400 mm and 800 mm are typical), while the diameter D_{11} can be 1,200 mm (values between 1,000 mm and 1,400 mm are typical). In this connection, the first roll 10 of the bridle 4 has the same diameter as the rolls 8 and 9 of the first bridle 3.

[0027] The second bridle 4 also has means 19 for measuring the tensile force in the metal strip 2 (torque measurement). The strip tension adjusted between the rolls 10 and 11 by suitable activation of the drives (not shown) of the rolls 10, 11 is at a level such that theoretically no surface layer plastic deformation of the strip to be stretched starts to occur yet. The following roll 11 of the bridle 4 has the significantly larger diameter D_{11} . This roll 11 builds up the strip tension to a level between more than 96% of the yield point tension and just less than 100% of the yield point tension. Since the

roll radius is finite, surface layer stretching due to bending of the strip cannot be excluded. However, it can be reduced to an acceptable level by the dimensioning of the diameter.

[0028] Between the roll 11 of the second bridle 4 and the following roll 12 of the third bridle 5, there is a relatively long unsupported length of strip, in which a nonuniform stress distribution over the width of the strip can be equalized by the increase in tension. In this location, stress peaks due to areas of unflatness can be equalized by microplastic deformation, but the actual stretching process does not yet occur here.

[0029] With the roll 12 that comes next in the direction of strip transport R, the strip tension is then raised to the level necessary for the desired tensile strain. The diameter D_{12} of this roll 12 is the same as the diameter D_{11} of roll 11. Since the starting level of the strip tension is already very high, negative effects due to hindered transverse contraction on roll 12 are virtually excluded. For this reason, the stretching interval between rolls 12 and 13 can also be very short, since equalization of stress is not necessary.

[0030] With the next bridle 6, it is possible either to lower the strip tension back to a level between 96% and just below 100% of the yield point tension and thus to apply no further stretching, or, alternatively, to impose additional tensile strain on the metal strip 2 in a systematic way here. Since the unsupported length of strip is again relatively long between the rolls 13 and 14, the last nonuniformities in the stress distribution can be removed here.

[0031] The bridle 6 is again equipped with a roll 14 of large diameter and a following roll 15 of small diameter and its configuration is mirror-inverted relative to bridle 4 upstream of the pair of stretcher leveling rolls 12, 13.

[0032] To allow detection of the strip tension, the bridle 6 is also provided with means 20 for measuring the tensile force. After the large-diameter roll 14 of the fourth bridle 6, a strip tension level is adjusted at which plastic deformation of the metal strip 2 is prevented as it is taken up on the small roll 15 that follows. The small roll 15 adjusts the strip tension level to the level required for the following strip tension measurement. The strip tension measurement is made by means 23 for measuring the tensile force.

[0033] The configuration of the last, fifth bridle 7 is again mirror-inverted relative to the first bridle 3. Its rolls 16, 17 have the same small roll diameter as rolls 10 and 15. This bridle 7 reduces the strip tension to the level desired or needed for the next section of the installation.

[0034] Measuring means 21 for determining the speed of conveyance v of the metal strip 2 are installed at the fourth bridle 6. The measuring means 21 transmit the measured value to an open-loop or closed-loop control system 22, which (as is shown in only a highly schematic way) acts on the drives of the bridles 3, 4, 5, 6, 7 in such a way that a desired speed is reached. The roll 14, at which the speed of conveyance or the strip speed is measured in the present case, thus acts as the "speedmaster" with a downstream speed-controlled main drive of the rolls or the tension roll sets.

[0035] The strip tension is thus maintained at a level between 96% of the yield point tension and just below 100% of the yield point tension upstream of the pair of stretcher

leveling rolls **12**, **13**; the remaining portion of the strip tension necessary to achieve the set amount of tensile strain is applied in the pair of stretcher leveling rolls **12**, **13**. Downstream of the pair of stretcher leveling rolls **12**, **13**, the strip tension is either reduced again to between 96% and just below 100% of the yield point tension or increased to achieve supplementary further tensile strain.

[0036] The last roll **11** of the bridle **4** (brake bridle) before the pair of stretcher leveling rolls **12**, **13** and the first roll **14** of the following bridle **6** (tension bridle) after the pair of stretcher leveling rolls **12**, **13** have the same diameter as the two rolls **12**, **13** of the bridle **5**. As explained above, this diameter is significantly greater than the diameter of the other rolls **8**, **9**, **10**, **15**, **16**, and **17**, all of which have the same diameter.

[0037] The strip tension in the bridle **4** upstream of the bridle **5** (stretcher leveling roll unit) and in the bridle **6** downstream of the bridle **5** is adjusted by means of strip tension measurement and torque measurement at the rolls in such a way that theoretically no surface layer plastic deformation occurs at the smaller of the two rolls **10** and **15** installed in the bridles **4** and **6**, respectively.

[0038] In the illustrated embodiment, the metal strip **2** has a stress between the two rolls **10** and **11** of about 55-70% of the yield point of the material. As described above, a tensile stress between 96% of the yield point and just below 100% of the yield point is present between the rolls **11** and **12**. This region is the prestretching zone. The first principal stretching zone is located between the rolls **12** and **13**. The second principal stretching zone is the section between rolls **13** and **14**, where a tensile stress between 96% of the yield point and just below 100% of the yield point is generally present. Between the rolls **14** and **15**, a tensile stress of 55-70% of the yield point of the material is again present (mirroring the situation between the two rolls **14** and **15**).

LIST OF REFERENCE SYMBOLS

[0039]	1 stretcher leveling device
[0040]	2 metal strip
[0041]	3 bridle
[0042]	4 bridle
[0043]	5 bridle
[0044]	6 bridle
[0045]	7 bridle
[0046]	8 roll
[0047]	9 roll
[0048]	10 roll
[0049]	11 roll
[0050]	12 roll
[0051]	13 roll
[0052]	14 roll
[0053]	15 roll
[0054]	16 roll
[0055]	17 roll

[0056]	18 means for measuring the tensile force
[0057]	19 means for measuring the tensile force
[0058]	20 means for measuring the tensile force
[0059]	21 measuring means
[0060]	22 open-loop or closed-loop control system
[0061]	23 means for measuring the tensile force
[0062]	R strip transport direction
[0063]	α contact roll wrap angle
[0064]	D ₈ diameter of roll 8
[0065]	D ₉ diameter of roll 9
[0066]	D ₁₀ diameter of roll 10
[0067]	D ₁₁ diameter of roll 11
[0068]	D ₁₂ diameter of roll 12
[0069]	D ₁₃ diameter of roll 13
[0070]	D ₁₄ diameter of roll 14
[0071]	D ₁₅ diameter of roll 15
[0072]	D ₁₆ diameter of roll 16
[0073]	D ₁₇ diameter of roll 17
[0074]	v speed of conveyance

1. A device (1) for the continuous stretcher leveling of metal strip (2), which device (1) has at least three bridles (3, 4, 5, 6, 7) in the direction of strip transport (R), with each bridle (3, 4, 5, 6, 7) having at least two rolls (8, 9; 10, 11; 12, 13; 14, 15; 16, 17), where the rolls (8, 9, 10, 11, 12, 13, 14, 15, 16, 17) are positioned in such a way that the metal strip (2) wraps around them over a contact roll wrap angle (α) of more than 180°, wherein at least the second bridle (4) in the direction of strip transport (R) has two rolls (10, 11) with different diameters (D₁₀, D₁₁).

2. A device in accordance with claim 1, wherein the second roll (11) of the second bridle (4), which is downstream of the first roll (10) of the second bridle (4) in the direction of strip transport (R), is the roll with the larger diameter (D₁₁).

3. A device in accordance with claim 1 or claim 2, wherein it has five bridles (3, 4, 5, 6, 7) with at least two rolls each (8, 9; 10, 11; 12, 13; 14, 15; 16, 17).

4. A device in accordance with claim 3, wherein the fourth bridle (6) in the direction of strip transport (R) has two rolls (14, 15) with different diameters (D₁₄, D₁₅).

5. A device in accordance with claim 4, wherein the downstream roll (15) of the fourth bridle (6) in the direction of strip transport (R) has the smaller diameter (D₁₅).

6. A device in accordance with any of claims 1 to 5, wherein the diameter of the large-diameter roll (11, 14) of the bridle (4, 6) is at least 1.25 times larger than the diameter of the small-diameter roll (10, 15).

7. A device in accordance with claim 6, wherein the diameter of the large-diameter roll (11, 14) of the bridle (4, 6) is at least 1.5 times larger than the diameter of the small-diameter roll (10, 15) and preferably twice as large.

8. A device in accordance with any of claims 3 to 7, wherein the third bridle (5) has two rolls (12, 13) with

diameters (D_{12} , D_{13}) that are the same as the diameters (D_{11} , D_{14}) of the larger rolls (11, 14) of the second and fourth bridles (4, 6).

9. A device in accordance with any of claims 3 to 8, wherein the first and fifth bridles (3, 7) each have two rolls (8, 9; 16, 17) with diameters (D_8 , D_9 ; D_{16} , D_{17}) that are the same as the diameters (D_{10} , D_{15}) of the smaller rolls (10, 15) of the second and fourth bridles (4, 6).

10. A device in accordance with any of claims 1 to 9, wherein means (18) for measuring the tensile force present in the metal strip (2) are installed after the first bridle (3) in the direction of strip transport (R).

11. A device in accordance with any of claims 1 to 10, wherein the second bridle (4) in the direction of strip transport (R) is equipped with means (19) for measuring the tensile force applied to the metal strip (2) by the rolls (10, 11).

12. A device in accordance with any of claims 3 to 10, wherein the fourth bridle (6) in the direction of strip transport (R) is equipped with means (20) for measuring the tensile force applied to the metal strip (2) by the rolls (14, 15).

13. A device in accordance with any of claims 3 to 12, wherein the fourth bridle (6) in the direction of strip transport (R) is equipped with measuring means (21) for measuring the speed of conveyance (v) of the metal strip (2), which means are connected with an open-loop or closed-

loop control system (22), which regulates or automatically controls the drives of at least some of the bridles (3, 4, 5, 6, 7) according to the determined speed of conveyance (v).

14. A method for operating a device (1) for the continuous stretcher leveling of metal strip (2), which device (1) has at least three bridles (3, 4, 5, 6, 7) in the direction of strip transport (R), with each bridle (3, 4, 5, 6, 7) having at least two rolls (8, 9; 10, 11; 12, 13; 14, 15; 16, 17), especially a device in accordance with any of claims 1 to 13, wherein, in the second bridle (4) in the strip transport direction (R), a tensile stress which is 96% to 100% of the yield point of the material of the metal strip (2) is built up in the metal strip (2).

15. A method in accordance with claim 14, wherein, in a device with five bridles (3, 4, 5, 6, 7), a tensile stress which is greater than 100% of the yield point of the material of the metal strip (2) is built up in the metal strip (2) in the third bridle (5) in the direction of strip transport (R).

16. A method in accordance with claim 15, wherein, in the fourth bridle (6) in the strip transport direction (R), a tensile stress which is 96% to 100% of the yield point of the material of the metal strip (2) is built up in the metal strip (2).

17. A method in accordance with claim 15, wherein, in the fourth bridle (6) in the strip transport direction (R), a tensile stress which is greater than 100% of the yield point of the material of the metal strip (2) is built up in the metal strip (2).

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